FIG. 1

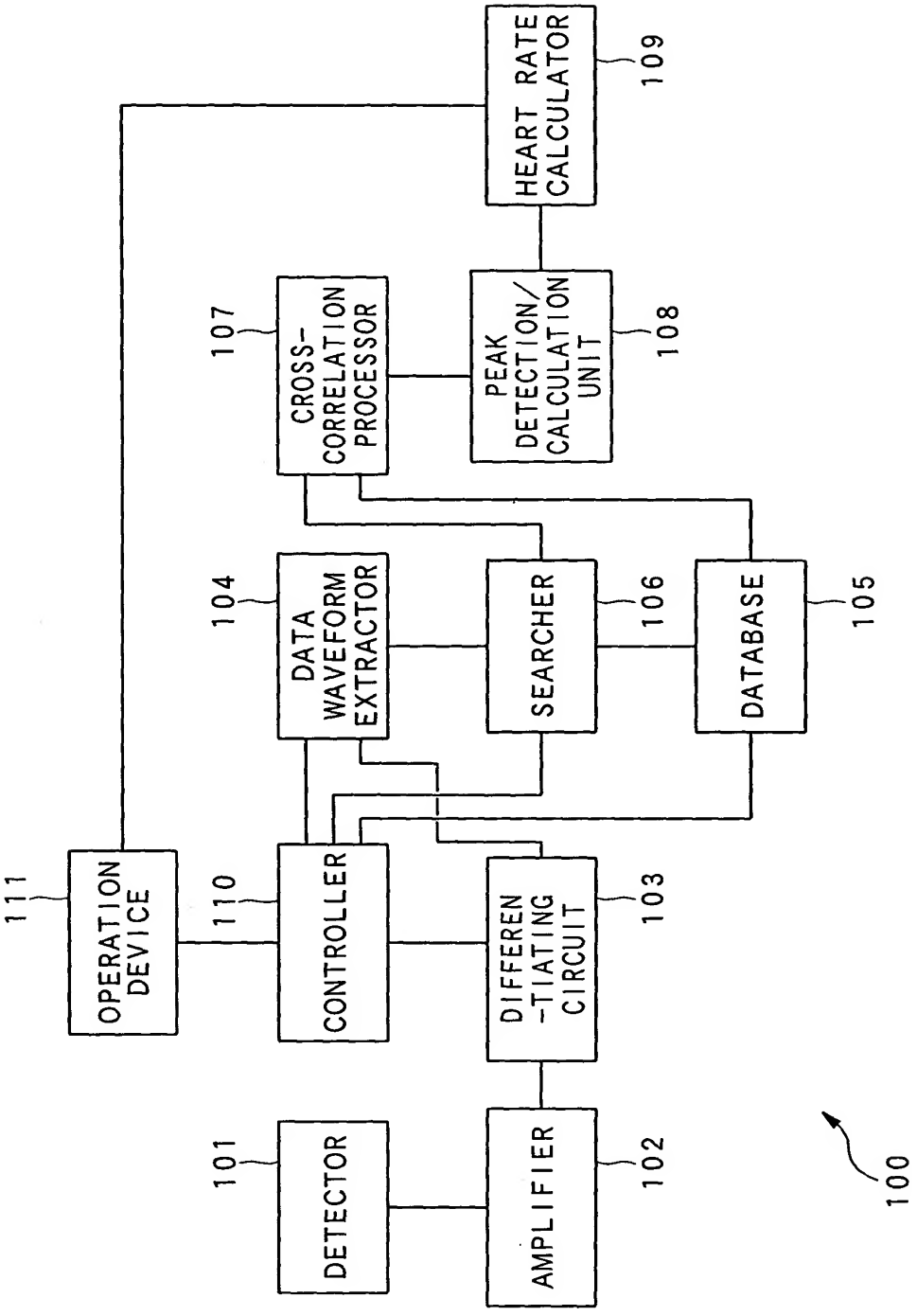

HEART RATE CALCULATOR
109
CROSS-CORRELATION PROCESSOR
107
PEAK DETECTION/CALCULATION UNIT
108
DATA WAVEFORM EXTRACTOR
104
SEARCHER
106
DATABASE
105
OPERATION DEVICE
111
CONTROLLER
110
DIFFEREN-TIATING CIRCUIT
103
DETECTOR
101
AMPLIFIER
102
100

FIG. 2

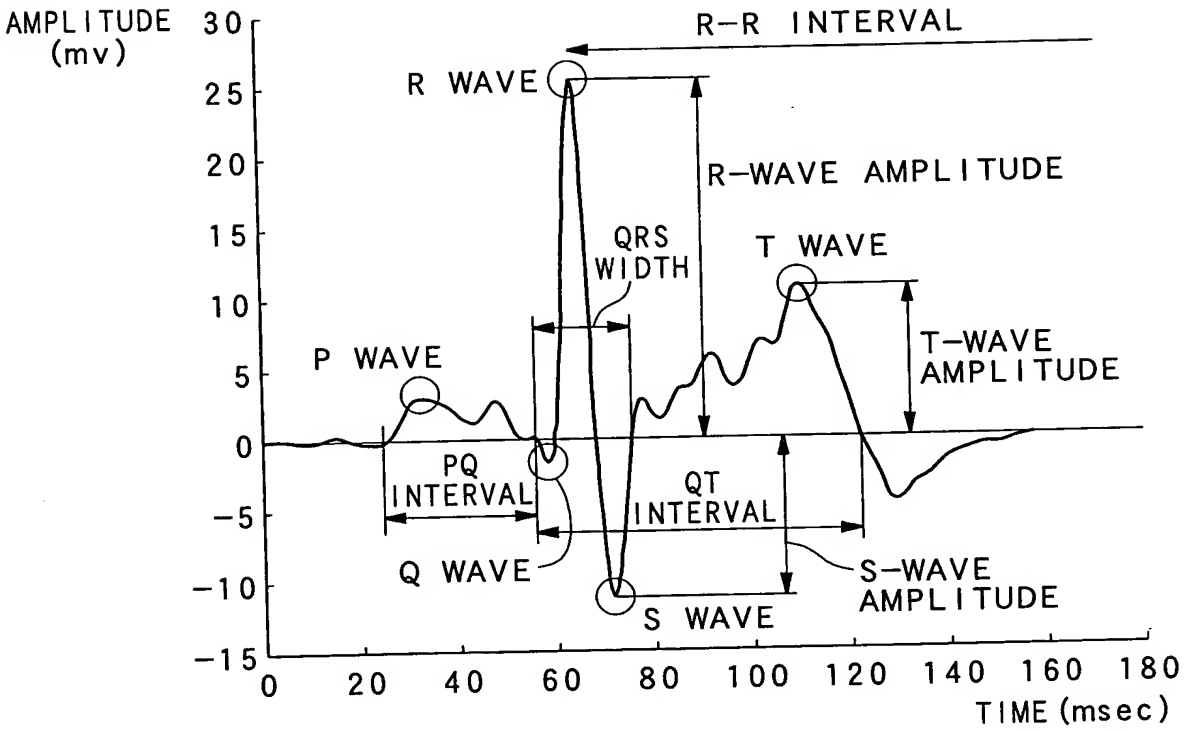

AMPLITUDE (mv)
30
25
20
15
10
5
0
−5
−10
−15
0
20
40
60
80
100
120
140
160
180
TIME (msec)
R−R INTERVAL
R WAVE
R−WAVE AMPLITUDE
QRS WIDTH
T WAVE
T−WAVE AMPLITUDE
P WAVE
PQ INTERVAL
QT INTERVAL
Q WAVE
S−WAVE AMPLITUDE
S WAVE

FIG. 3A

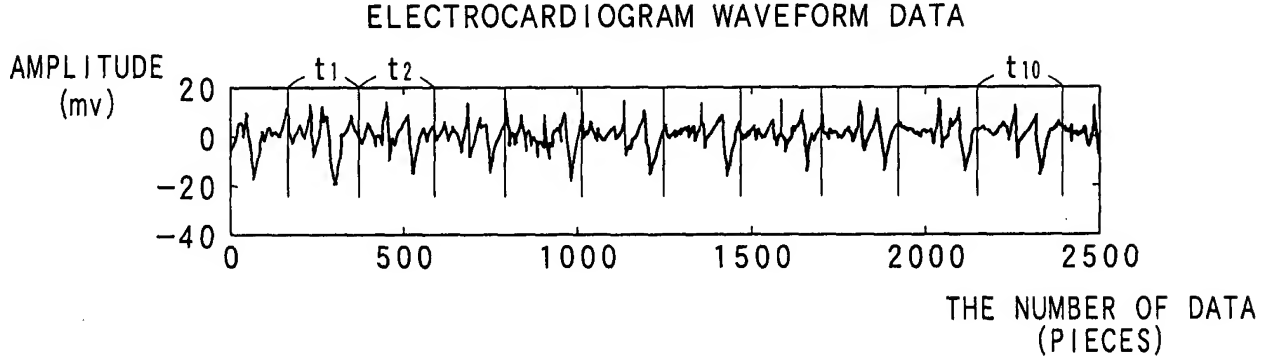


FIG. 3B

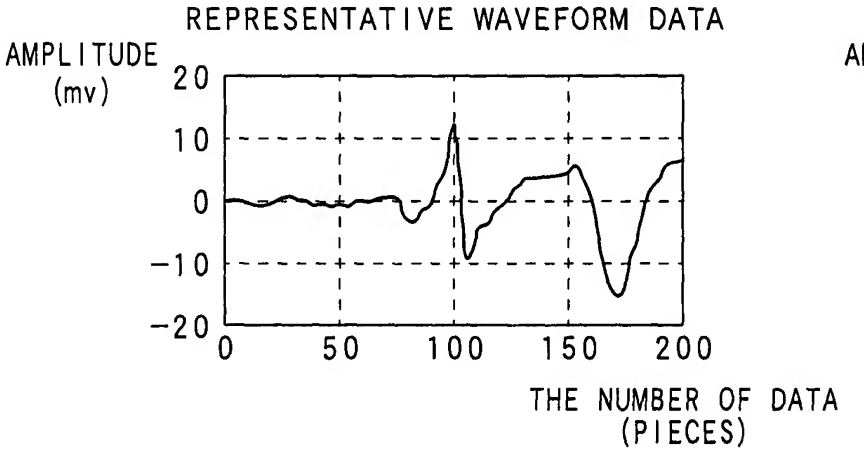


FIG. 3C

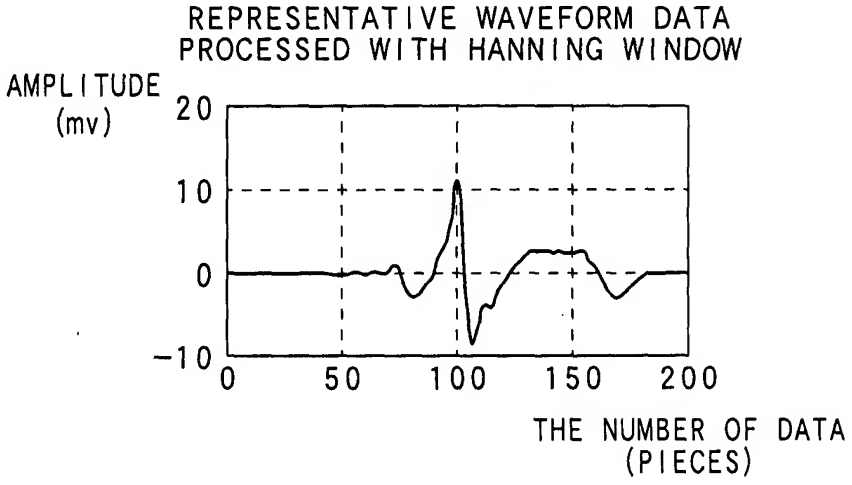


FIG. 4

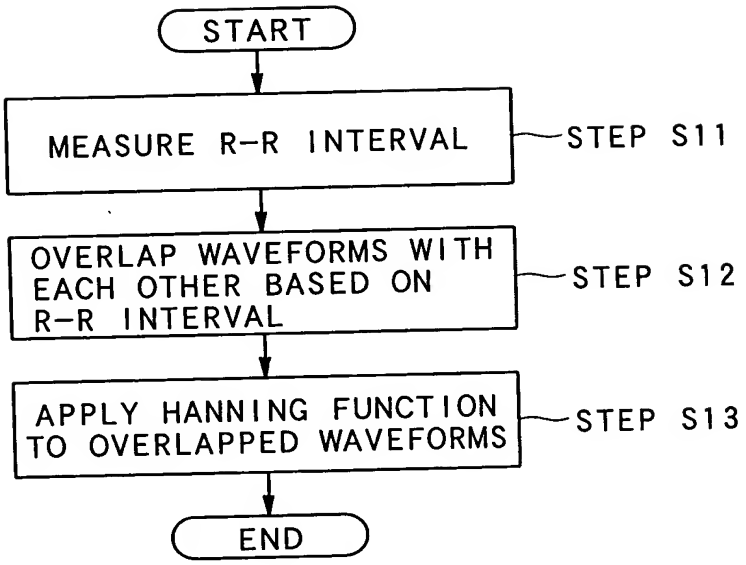

START
MEASURE R-R INTERVAL
STEP S11
OVERLAP WAVEFORMS WITH EACH OTHER BASED ON R-R INTERVAL
STEP S12
APPLY HANNING FUNCTION TO OVERLAPPED WAVEFORMS
STEP S13
END

FIG. 5A

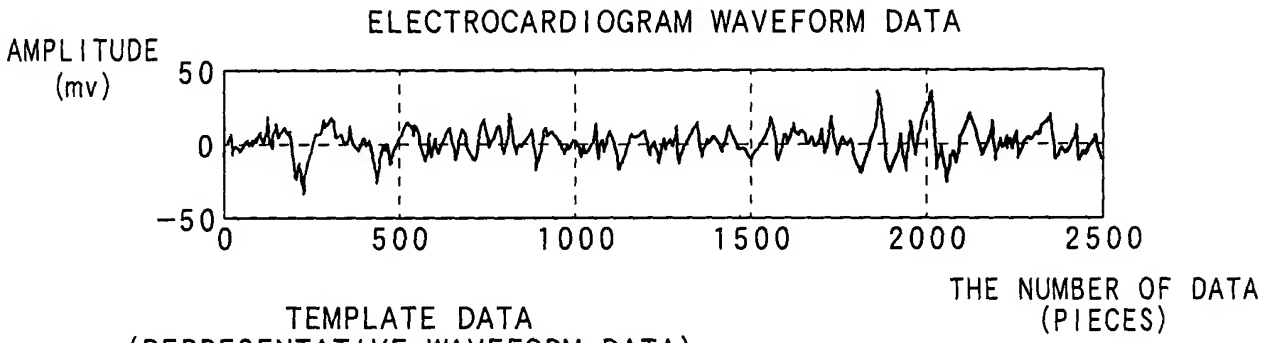


FIG. 5B

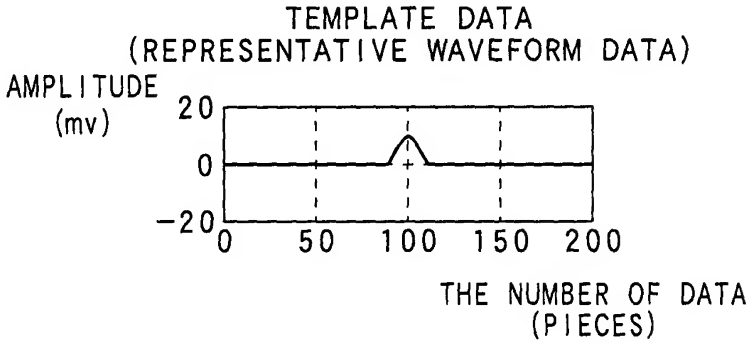


FIG. 5C

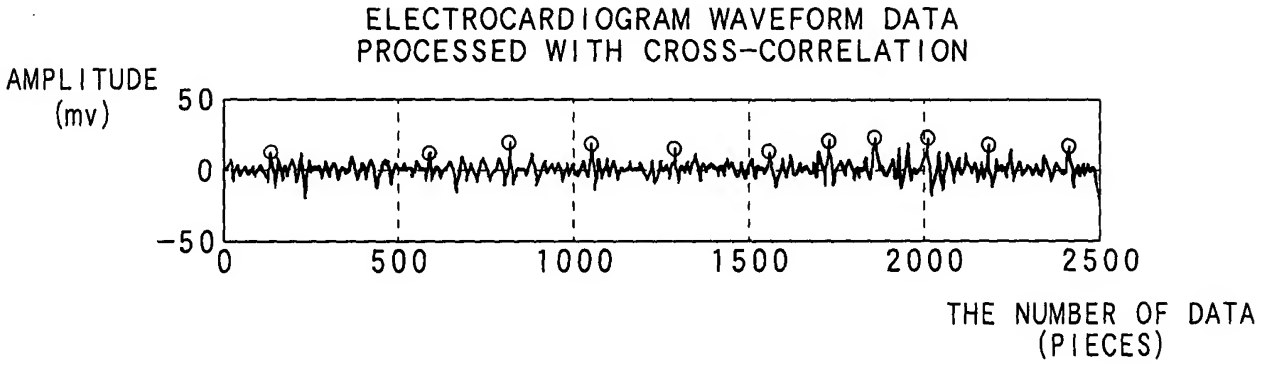


FIG. 6A

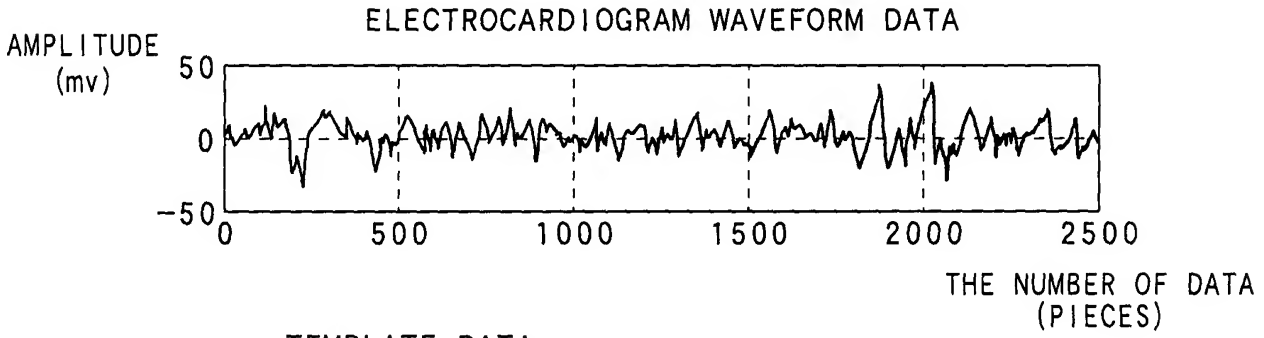


FIG. 6B

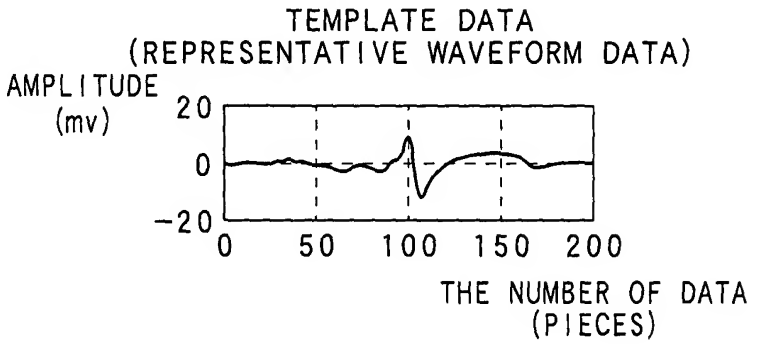


FIG. 6C

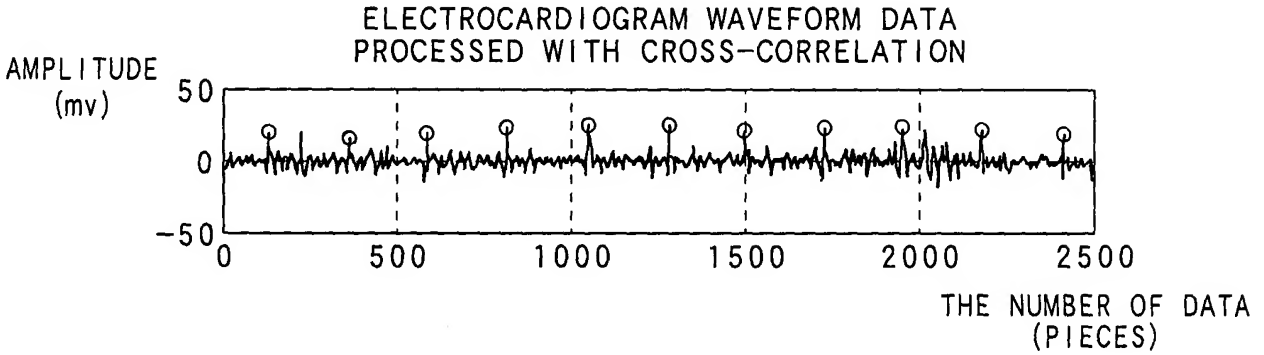


FIG. 7

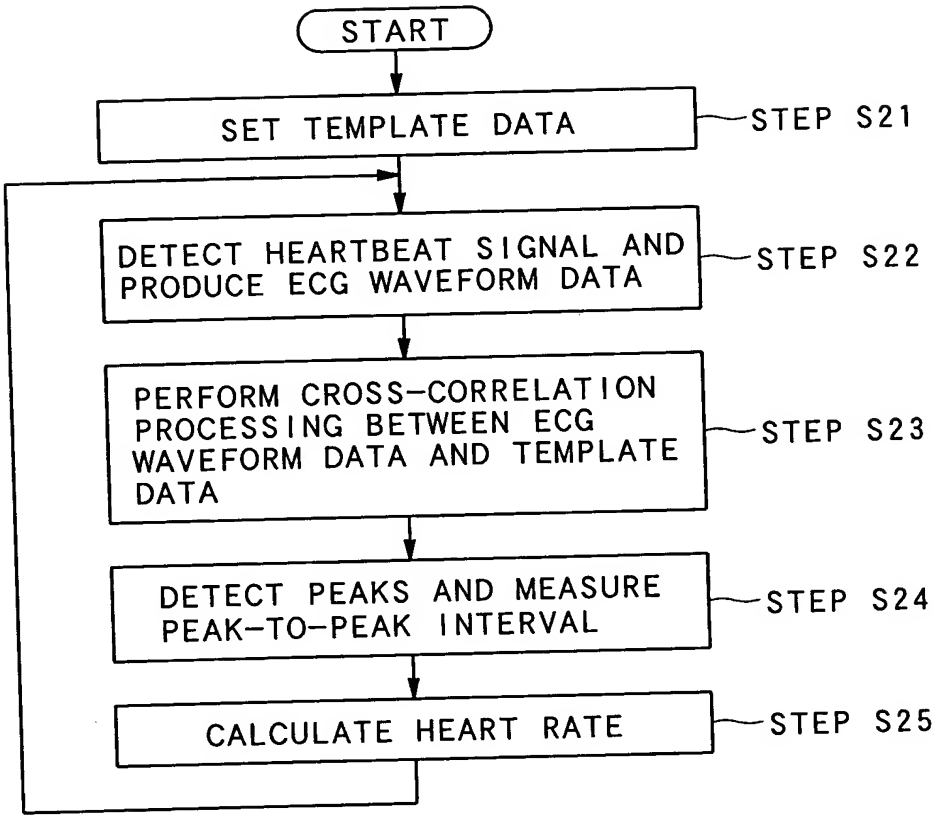

START
SET TEMPLATE DATA
STEP S21
DETECT HEARTBEAT SIGNAL AND PRODUCE ECG WAVEFORM DATA
STEP S22
PERFORM CROSS-CORRELATION PROCESSING BETWEEN ECG WAVEFORM DATA AND TEMPLATE DATA
STEP S23
DETECT PEAKS AND MEASURE PEAK-TO-PEAK INTERVAL
STEP S24
CALCULATE HEART RATE
STEP S25

FIG. 8

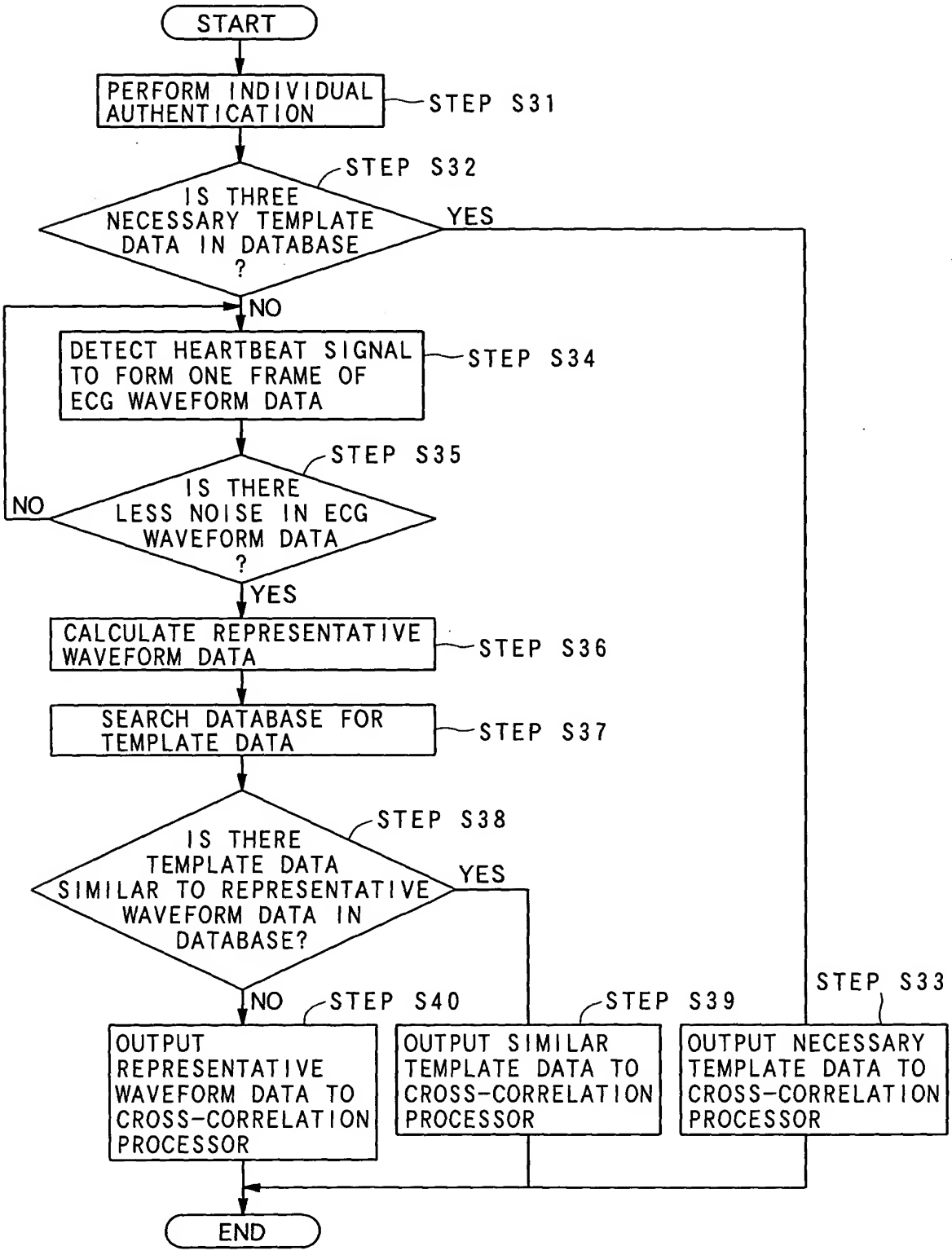

START
PERFORM INDIVIDUAL AUTHENTICATION
STEP S31
STEP S32
IS THREE NECESSARY TEMPLATE DATA IN DATABASE ?
YES
NO
DETECT HEARTBEAT SIGNAL TO FORM ONE FRAME OF ECG WAVEFORM DATA
STEP S34
STEP S35
IS THERE LESS NOISE IN ECG WAVEFORM DATA ?
NO
YES
CALCULATE REPRESENTATIVE WAVEFORM DATA
STEP S36
SEARCH DATABASE FOR TEMPLATE DATA
STEP S37
STEP S38
IS THERE TEMPLATE DATA SIMILAR TO REPRESENTATIVE WAVEFORM DATA IN DATABASE?
YES
NO
STEP S40
STEP S39
STEP S33
OUTPUT REPRESENTATIVE WAVEFORM DATA TO CROSS-CORRELATION PROCESSOR
OUTPUT SIMILAR TEMPLATE DATA TO CROSS-CORRELATION PROCESSOR
OUTPUT NECESSARY TEMPLATE DATA TO CROSS-CORRELATION PROCESSOR
END

FIG. 9

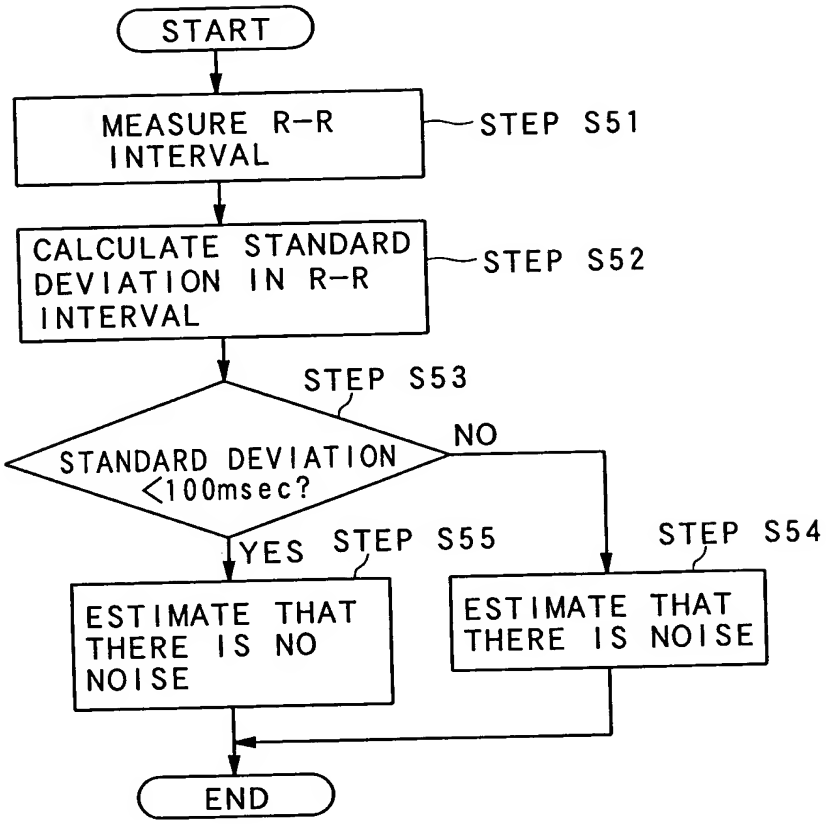

START
MEASURE R-R INTERVAL
STEP S51
CALCULATE STANDARD DEVIATION IN R-R INTERVAL
STEP S52
STEP S53
STANDARD DEVIATION <100msec?
NO
YES
STEP S55
STEP S54
ESTIMATE THAT THERE IS NO NOISE
ESTIMATE THAT THERE IS NOISE
END

FIG. 10

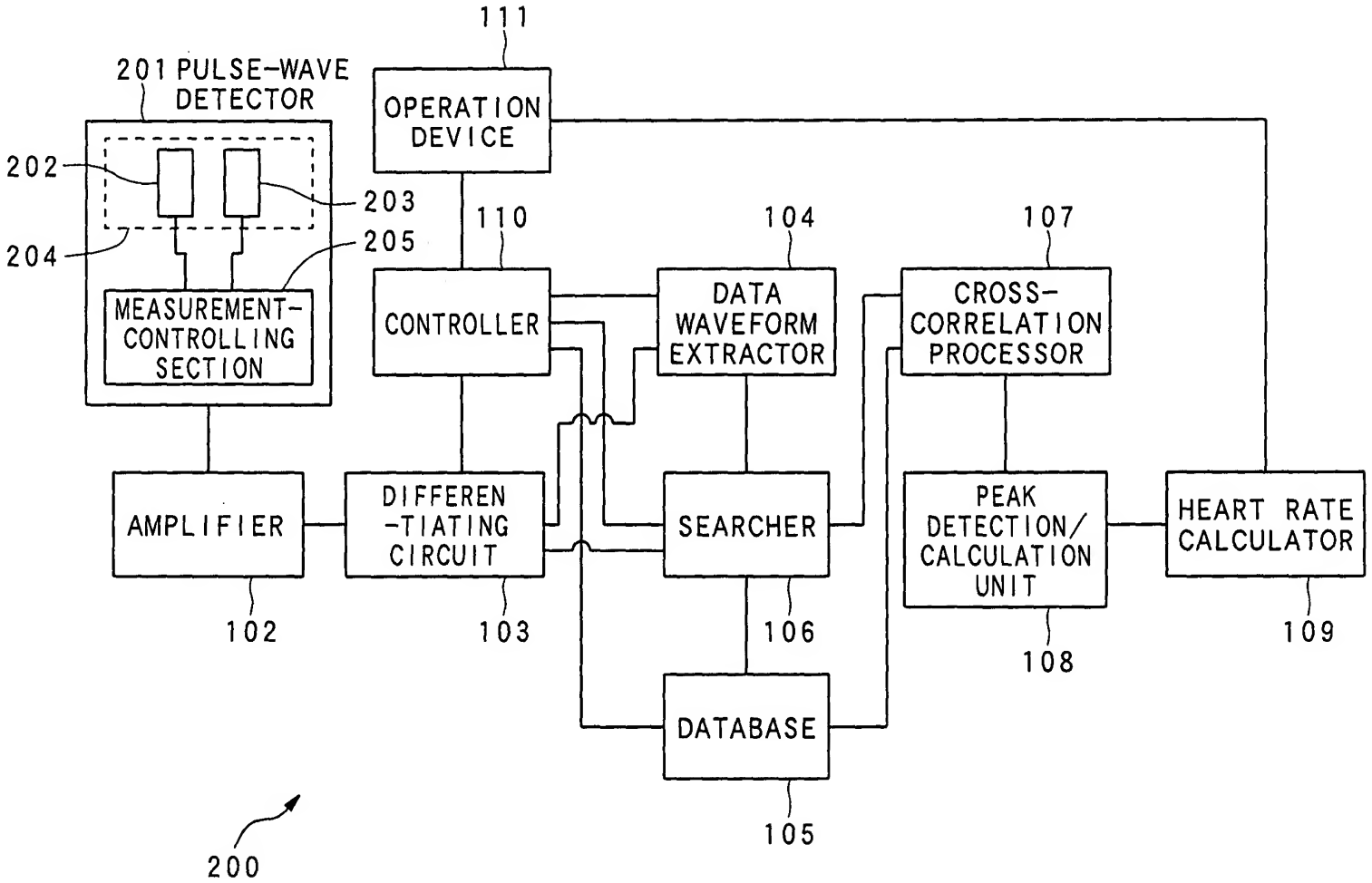

111
201 PULSE-WAVE DETECTOR
OPERATION DEVICE
202
203
204
205
110
104
107
MEASUREMENT-CONTROLLING SECTION
CONTROLLER
DATA WAVEFORM EXTRACTOR
CROSS-CORRELATION PROCESSOR
AMPLIFIER
DIFFEREN-TIATING CIRCUIT
SEARCHER
PEAK DETECTION/CALCULATION UNIT
HEART RATE CALCULATOR
102
103
106
108
109
DATABASE
105
200

FIG. 11

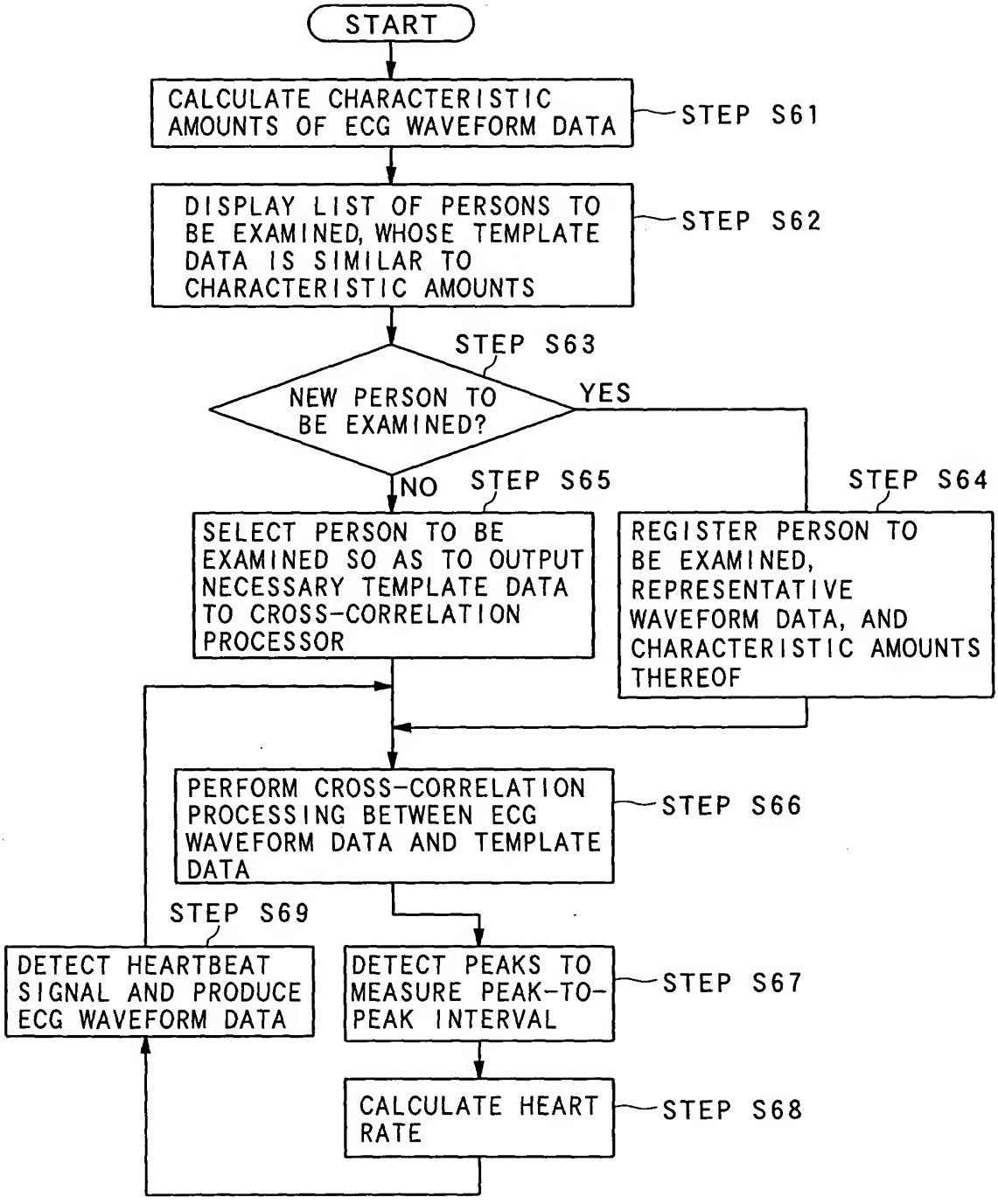

START
CALCULATE CHARACTERISTIC AMOUNTS OF ECG WAVEFORM DATA
STEP S61
DISPLAY LIST OF PERSONS TO BE EXAMINED, WHOSE TEMPLATE DATA IS SIMILAR TO CHARACTERISTIC AMOUNTS
STEP S62
STEP S63
NEW PERSON TO BE EXAMINED?
YES
NO
STEP S65
SELECT PERSON TO BE EXAMINED SO AS TO OUTPUT NECESSARY TEMPLATE DATA TO CROSS-CORRELATION PROCESSOR
STEP S64
REGISTER PERSON TO BE EXAMINED, REPRESENTATIVE WAVEFORM DATA, AND CHARACTERISTIC AMOUNTS THEREOF
PERFORM CROSS-CORRELATION PROCESSING BETWEEN ECG WAVEFORM DATA AND TEMPLATE DATA
STEP S66
STEP S69
DETECT HEARTBEAT SIGNAL AND PRODUCE ECG WAVEFORM DATA
DETECT PEAKS TO MEASURE PEAK-TO-PEAK INTERVAL
STEP S67
CALCULATE HEART RATE
STEP S68

FIG. 12

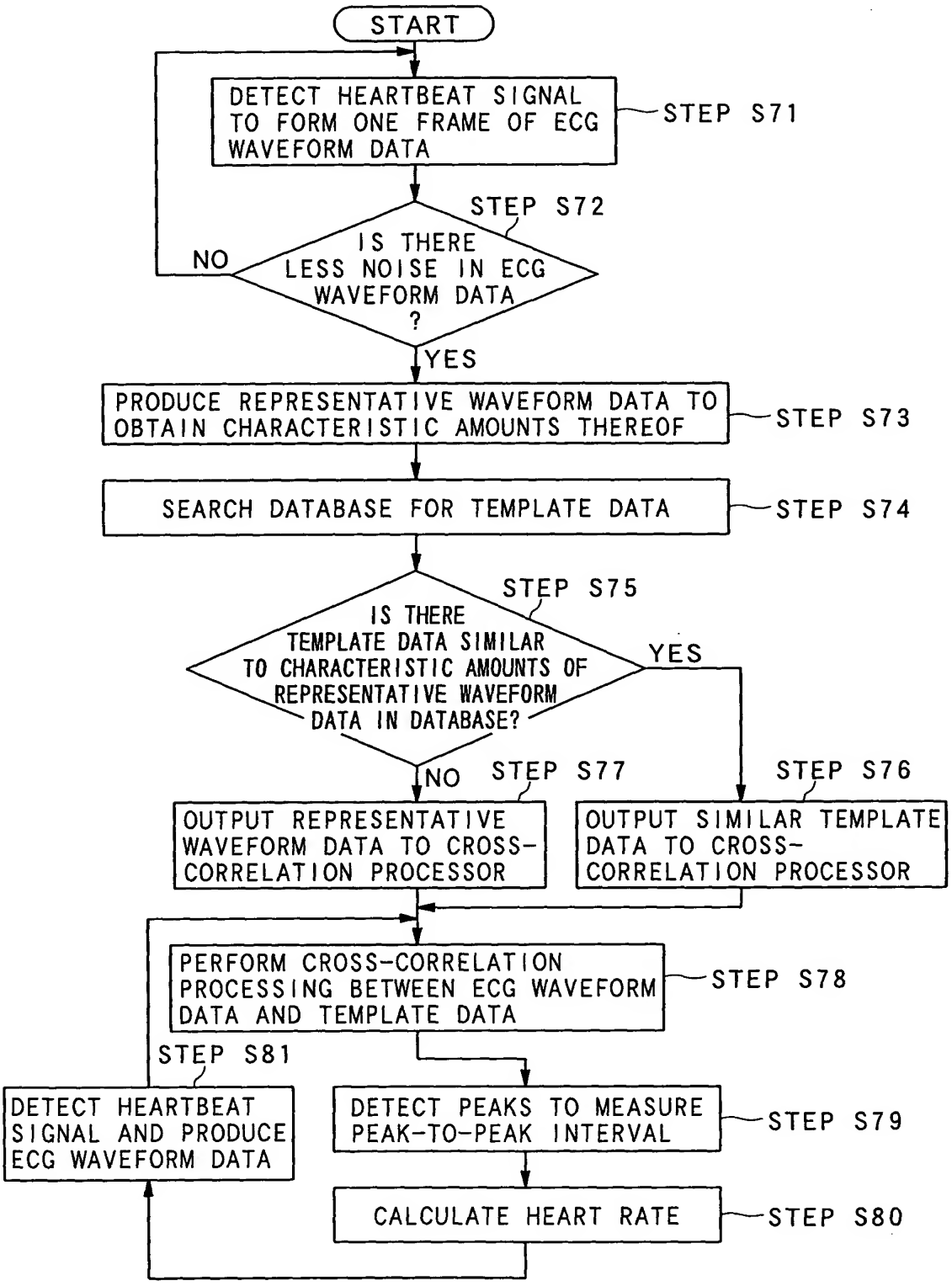
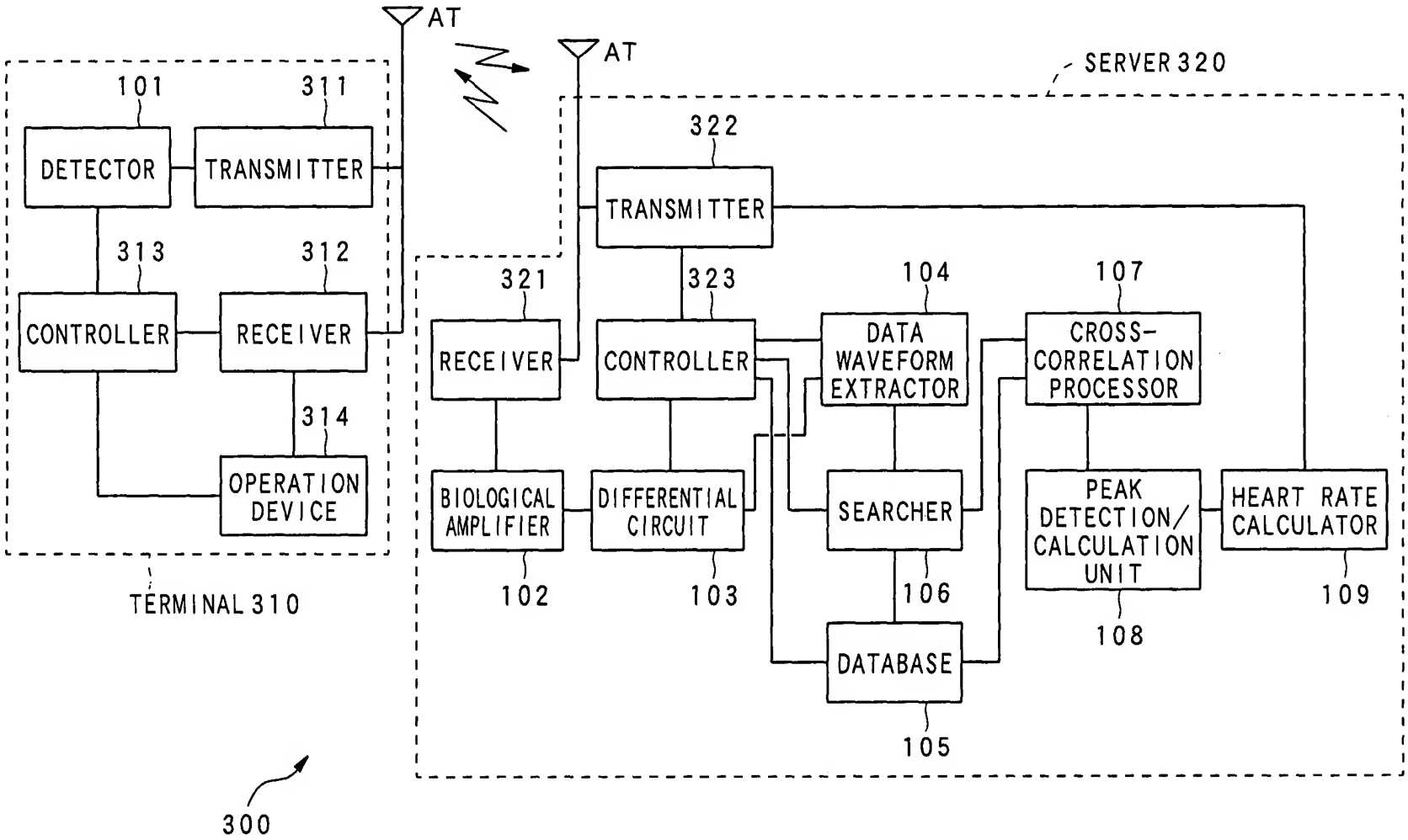

START
DETECT HEARTBEAT SIGNAL TO FORM ONE FRAME OF ECG WAVEFORM DATA
STEP S71
STEP S72
IS THERE LESS NOISE IN ECG WAVEFORM DATA ?
NO
YES
PRODUCE REPRESENTATIVE WAVEFORM DATA TO OBTAIN CHARACTERISTIC AMOUNTS THEREOF
STEP S73
SEARCH DATABASE FOR TEMPLATE DATA
STEP S74
STEP S75
IS THERE TEMPLATE DATA SIMILAR TO CHARACTERISTIC AMOUNTS OF REPRESENTATIVE WAVEFORM DATA IN DATABASE?
YES
NO
STEP S77
STEP S76
OUTPUT REPRESENTATIVE WAVEFORM DATA TO CROSS-CORRELATION PROCESSOR
OUTPUT SIMILAR TEMPLATE DATA TO CROSS-CORRELATION PROCESSOR
PERFORM CROSS-CORRELATION PROCESSING BETWEEN ECG WAVEFORM DATA AND TEMPLATE DATA
STEP S78
STEP S81
DETECT HEARTBEAT SIGNAL AND PRODUCE ECG WAVEFORM DATA
DETECT PEAKS TO MEASURE PEAK-TO-PEAK INTERVAL
STEP S79
CALCULATE HEART RATE
STEP S80

FIG. 13


AT
AT
SERVER 320
101
311
DETECTOR
TRANSMITTER
313
312
CONTROLLER
RECEIVER
314
OPERATION DEVICE
TERMINAL 310
322
TRANSMITTER
321
323
104
107
RECEIVER
CONTROLLER
DATA WAVEFORM EXTRACTOR
CROSS-CORRELATION PROCESSOR
BIOLOGICAL AMPLIFIER
DIFFERENTIAL CIRCUIT
SEARCHER
PEAK DETECTION/ CALCULATION UNIT
HEART RATE CALCULATOR
102
103
106
108
109
DATABASE
105
300